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RESPONSE OF CROWNVETCH PLANTED ON ANTHRACITE BREAKER REFUSE

Abstract. Lime applications were essential to establishment of crownvetch (*Coronilla varia* L.) on coal breaker refuse in the Pennsylvania Anthracite Region, and mulch treatments were highly beneficial. Fertilizer applications had only slight effect on either establishment or growth.

The 112,000 acres of Pennsylvania's anthracite coal-mine spoils create a complex of unsightly, barren, and nonproductive landscapes. Many people think that trees or other vegetative cover would greatly contribute to the aesthetics and economic growth of the area. And studies have shown that a number of forest trees, both native and exotic, will survive and grow on most strip-mine spoils.

However, some 27,000 acres of black, carbonaceous, highly acid, deep-mine spoils create unique problems in slope stability, air pollution, stream pollution, siltation, and aesthetics. Perhaps the most conspicuous type of deep-mine spoil consists of coal-breaker refuse. Here few experimental plantings of trees have succeeded. However, we have recent evidence that at least some of the breaker-refuse areas will support plant growth,[1] especially if properly treated.[2]

We made a study to determine whether crownvetch (*Coronilla varia* L.) could be established on coal-breaker refuse by seeding or by planting crowns and using several lime, fertilizer, and mulch treatments; and if

[1]Czapowskyj, Miroslaw. AN EXPERIMENTAL STUDY OF THE SURVIVAL OF FOREST TREE SPECIES PLANTED ON ANTHRACITE MINE SPOILS IN PENNSYLVANIA. Unpublished office report, Northeastern Forest Experiment Station, 1967.
Schramm, J. R. PLANT COLONIZATION STUDIES ON BLACK WASTES FROM ANTHRACITE MINING IN PENNSYLVANIA. Trans. Amer. Philos. Soc. New Series, Part 1, 56 pp., illus., 1966.
[2]Czapowskyj, Miroslaw. EARLY RESPONSE OF JAPANESE LARCH AND RED PINE PLANTED ON TREATED ANTHRACITE BREAKER REFUSE. Unpublished office report, Northeastern Forest Experiment Station, 1967.

Stand of crownvetch growing on lime-treated coal-breaker refuse 2 years after planting.

so, whether the plants would grow well enough to provide quick and effective cover.

Our field study was begun in the spring of 1965 on coal-breaker refuse deposited on land owned by the Greenwood Stripping Company in Tamaqua, Pennsylvania. The physical and chemical characteristics of this spoil are probably typical of most coal-breaker refuse banks in the Anthracite Region.

Site

This refuse consists of medium to small pieces of very dark to black, highly pyritic, carbonaceous shales, slates, siltstones, and coal fragments. The top of the refuse bank is level and somewhat compacted by truck traffic. An analysis of the refuse revealed pH values ranging from 2.7 to 4.0, extremely low fertility, negligible amounts of organic matter, and about 25 percent content of soil-sized particles (less than 2 mm. in diameter).

Study Design and Establishment

The field arrangement was a split-split-plot design with three replicates. Seeding and planting were set up separately. We had six blocks, three each for seeding and planting. Each block, 30 by 60 feet, was

divided into three plots for lime treatments; each of these was divided into three subplots for fertilizer treatments; and each of these was split in two for mulch treatments. Thus, the ultimate units were 10 by 10 feet. Lime and fertilizer treatments were randomly assigned, but the mulch treatments were deliberately grouped to lessen the problem of holding the mulch in place.

The treatments consisted of all combinations of three levels of hydrated lime, three levels of 5-10-5 fertilizer, and two levels of straw mulch, as follows:

Lime—0, 2.5, and 5.0 tons per acre.

Fertilizer—0, 250, and 500 pounds per acre.

Mulch—0, and 1 bale of straw per block.

The liming rates were based on lime-requirement data; the 2.5- and 5.0-ton rates were calculated to raise the pH to about 6.0 and 6.5 respectively. Rates for fertilizer and mulch represented arbitrary judgments of reasonable amounts.

Lime and fertilizer were applied with a calibrated seed and fertilizer spreader shortly after the spring thaw. The mulch was spread by hand after the seeding and planting were done.

In the seeding, the seeds were broadcast by hand at a rate of 15 pounds per acre, and the inoculant of nodule-forming bacteria for this leguminous plant was added immediately after. In the planting, 25 two-year-old crowns, each including 8 to 10 inches of taproot, were hand planted with mattock at 2-by-2-foot spacing in each sub-subplot. Each block thus contained 450 crowns, and the entire planting in 1965 totaled 1,350 crowns.

It soon became obvious in 1965 that the seeding was a complete failure. So to provide a replicate in time and thereby strengthen the data on establishment by planting, the three originally seeded blocks were planted in the spring of 1966. This raised the total of crowns in the study to 2,700. No additional lime, fertilizer, or mulch were added for the 1966 planting.

Measurements

We measured survival and ground cover after each growing season. The number of living plants within each sub-subplot was counted and converted to percent survival. Ground cover was determined by randomly placing a 24-inch ruler on top of the somewhat circular spreading plant, measuring its diameter in three directions, and computing an average diameter. The ground-cover area of the plants was later calculated and

converted to a percentage of the sub-subplot area. The computed survival and ground-cover data were then transformed into arcsine values that we analyzed statistically by analysis of variance.

Results and Discussions

The treatments produced distinct patterns and striking differences in survival and ground-cover percentages of the planted crownvetch (tables 1 and 2). Lime had by far the strongest effect. Both the 2.5- and 5.0-ton treatments increased survival and ground cover many-fold. The two treatments were about equally beneficial, so they are not shown separately in the summary of statistically significant effects (table 3). Because crownvetch, like most legumes, is known to require a relatively high pH and high available calcium for best growth, the strong response to lime was what we expected.

From the nearly equal responses to the 2.5- and 5.0-ton applications of lime, we infer that the smaller amount was ample for maximum benefits. Further, this suggests that less than 2.5 tons per acre might be adequate.

Table 1. — *Percent survival of crownvetch planted in 1965 and 1966*
(Average of three replications)

Fertilizer (lbs./acre)	Lime in tons/acre					
	0		2.5		5.0	
	Mulch		Mulch		Mulch	
	None	Straw	None	Straw	None	Straw
	1965 PLANTING First Growing Season					
0	15	21	89	95	92	97
250	11	15	83	95	84	93
500	5	11	89	92	85	88
	1965 PLANTING Second Growing Season					
0	0	8	79	88	87	92
250	1	8	79	89	80	80
500	1	1	84	92	77	88
	1966 PLANTING First Growing Season					
0	8	1	48	52	65	61
250	3	0	60	53	56	52
500	3	0	55	56	68	60

Table 2. — *Percent of ground cover produced by crownvetch planted in 1965 and 1966*
(Average of three replications)

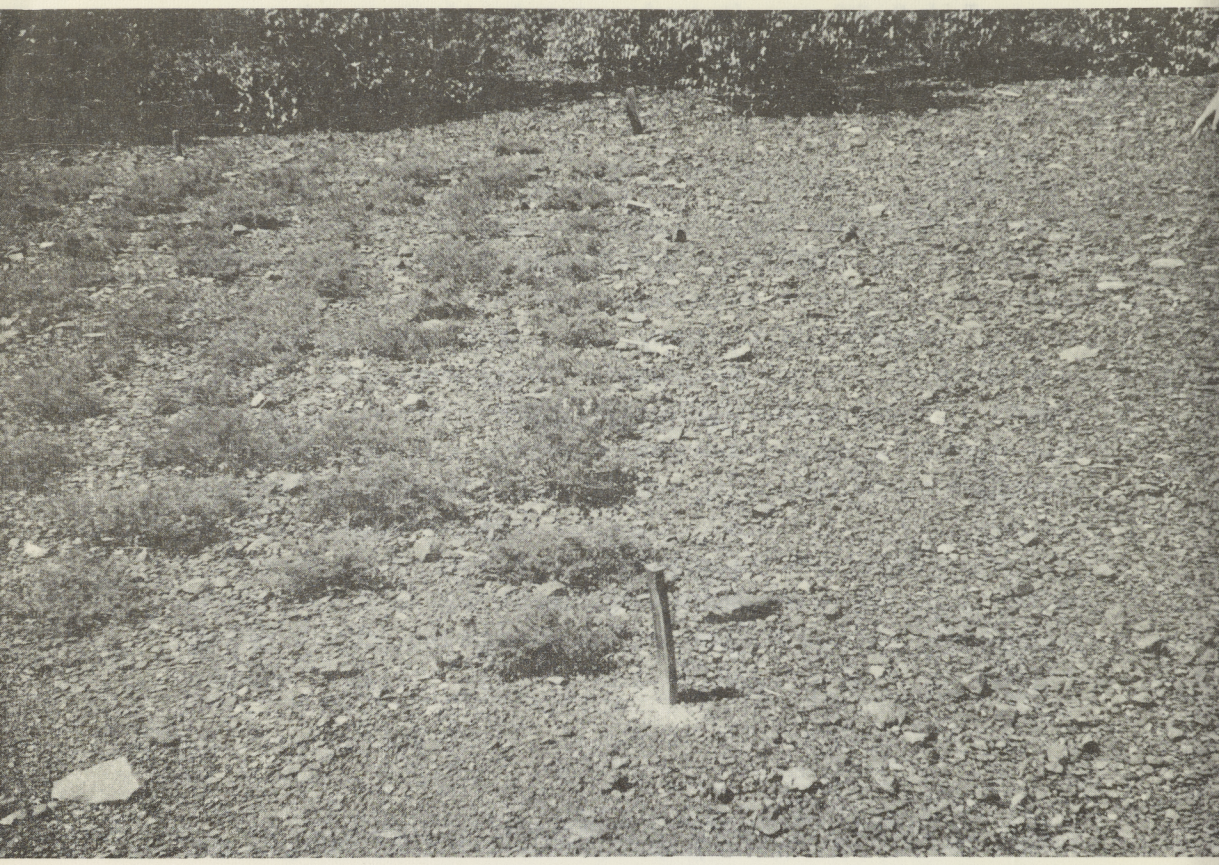
Fertilizer (lbs./acre)	Lime in tons/acre					
	0		2.5		5.0	
	Mulch		Mulch		Mulch	
	None	Straw	None	Straw	None	Straw
	1965 PLANTING First Growing Season					
0	0.2	0.5	3.8	10.1	5.7	8.4
250	.2	.7	4.9	17.3	7.2	12.5
500	.1	.1	6.5	11.9	6.4	12.3
	1965 PLANTING Second Growing Season					
0	.0	.4	4.5	7.8	4.1	9.1
250	.0	.6	5.3	13.0	6.7	9.6
500	.1	.0	6.1	9.8	5.2	11.0
	1966 PLANTING First Growing Season					
0	.1	.1	1.6	3.1	1.6	3.0
250	.1	.0	1.5	2.0	1.3	2.2
500	.0	.0	1.5	2.5	1.8	3.0

Although lime was applied primarily to neutralize the acidity of the refuse, this treatment probably also supplied nutrient calcium and increased the availability of other nutrient elements in the spoil.

The lime effects reported here are short-term effects. We do not know how long the effects of lime will last. The high pyrite content of these spoils gives them an enormous potential for acid production, so the pH may revert to its former level within a few years.

Mulch, although not so essential to success as lime, did prove to have value in establishing crownvetch. Mulched plots produced almost twice as much ground cover as unmulched plots, and in the 1965 planting survival was about 10 percent higher on the mulched plots. In the 1966 planting, the effects of mulch on survival were somewhat inconsistent, apparently because the mulch was repeatedly blown off by wind.

Statistical analysis of data also revealed a significant effect of lime-mulch interaction on the percent of ground cover for both plantings during their first growing season (table 3). Although mulch increased ground cover both with and without the addition of lime, the increase was much smaller when no lime was applied. Lime was such an impor-



The area at left, treated with lime, shows a good stand of crownvetch. But on the untreated area at right, no crownvetch has survived.

Table 3. — *Factors significantly affecting the survival and ground cover of planted crownvetch*

Planting year	Dependent	Variables			
		Independent			
		Lime	Mulch	Lime x mulch	Fertilizer
	FIRST GROWING SEASON				
1965	Survival	*	*	—	—
	Ground cover	*	*	*	*
	SECOND GROWING SEASON				
1965	Ground cover	*	*	—	—
	Survival	*	*	—	—
	FIRST GROWING SEASON				
1966	Survival	*	—	—	—
	Ground cover	*	*	*	—

*Significant at 5-percent level.

tant factor that, when none was applied, the ground cover was practically zero whether or not mulch was present.

The fertilizer treatments produced so small an increase in percent of ground cover that it was scarcely evident. The fertilizer effect was statistically significant only during the first year of the 1965 planting (table 3). Since the natural fertility of the breaker refuse is known to be extremely low, fertilizer was expected to produce a substantial response. Probably the reason why this did not occur was that the plantings were established during a prolonged drought period. 1966 was especially dry, and this is reflected in poorer survival and growth during that year than in 1965 (tables 1 and 2).

In summary: Lime was highly beneficial—in fact essential—in establishing crownvetch on coal-breaker refuse ranging in acidity below pH 4.0. Mulch also was beneficial, but not so essential as lime. Mulch effects showed up more in growth than in survival. Fertilizer had little effect, probably because of drought, which caused moisture to be a limiting factor. The plants could reasonably be expected to show a greater response to fertilizer during years of more abundant rainfall.

—MIROSLAW M. CZAPOWSKYJ[3]
JOHN P. MIKULECKY
EDWARD A. SOWA

[3]The authors are respectively Soil Scientist, Northeastern Forest Experiment Station; Forester, Pennsylvania Power and Light Company; and Forestry Research Technician, Northeastern Forest Experiment Station.

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